

The Effect of Nano-Sized Metal Deposits on TiO₂ on the Photocatalytic Activity and Mechanism

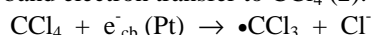
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TiO₂ photocatalysis has been extensively studied for its environmental applications and demonstrated to be a technically viable clean-up process (1). The main drawbacks of the low quantum yields and the lack of visible-light utilization, however, hinder its widespread acceptance as a practical remediation technology. Various approaches have been attempted to enhance the photocatalytic efficiency of TiO₂, which include metal-ion doping, metallization, and sensitization.

In this study, we investigated and compared the effects of depositing nano-sized metal particles (M: Pt, Au) on TiO₂ in three different aquatic photocatalytic systems: (1) dye-sensitized M/TiO₂ for the visible light photocatalytic degradation of perchlorinated compounds, (2) M/TiO₂ photocatalyst for ammonia removal, and (3) M/TiO₂ photocatalyst for trichloroacetate (TCA) degradation. The Pt and Au particles were photodeposited on TiO₂ (Degussa P25) with a typical loading of ca. 0.2 wt%. The transmission electron microscopic (TEM) images showed that Pt particles with a size range of 1-2 nm were well dispersed on TiO₂ particles (20-30 nm diameter).

Figure 1 exhibits the dramatic effect of the platinization of the sensitized TiO₂ on the visible light-induced dechlorination of CCl₄. The dechlorination initiates by the conduction band electron transfer to CCl₄ (2).



The presence of Pt deposits on TiO₂ in this case reduces the fast back electron transfer to the oxidized dye and enhances the interfacial electron transfer to CCl₄. The Pt/TiO₂ was also very effective in photocatalytic denitrification of ammonia as shown in Figure 2. While the pure TiO₂ almost quantitatively transformed ammonia into nitrite and nitrate (Fig. 2a), Pt/TiO₂ converted NH₃ into N₂ with reducing the total nitrogen concentration in the suspension (Fig. 2b). The evolution of N₂ gas was confirmed by detecting ³⁰N₂ using GC/MS from ¹⁵NH₃ conversion. Au/TiO₂ did not exhibit such denitrification effect. The photocatalytic degradation of TCA on Pt/TiO₂ was significantly different from that on pure TiO₂ with showing different product distribution. In the above three photocatalytic systems, both the photocatalytic activity and mechanism changed when Pt was deposited on TiO₂. Although the platinization of TiO₂ has been widely studied, its effect on the photocatalytic mechanism is not well understood. The role of metals and their effect on the photocatalytic reaction system will be discussed.

REFERENCES

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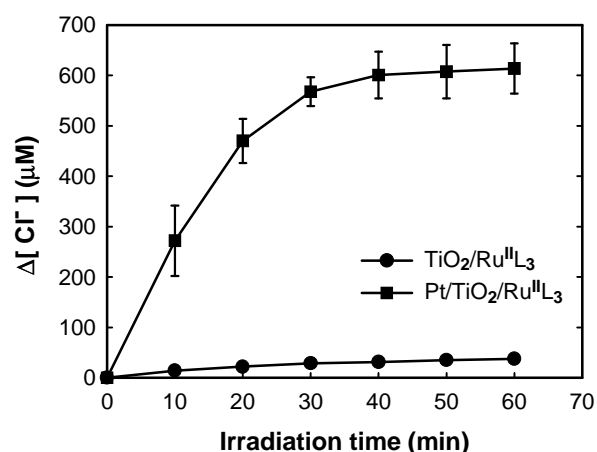


Figure 1. Chloride production from CCl₄ degradation on TiO₂/Ru^{II}L₃ and Pt/TiO₂/Ru^{II}L₃ under visible light illumination. The experimental conditions were: [TiO₂] = 0.5 g/L, [Ru^{II}L₃]_i = 10 μM, [CCl₄]_i = 1 mM, pH_i = 3, and initially N₂-saturated.

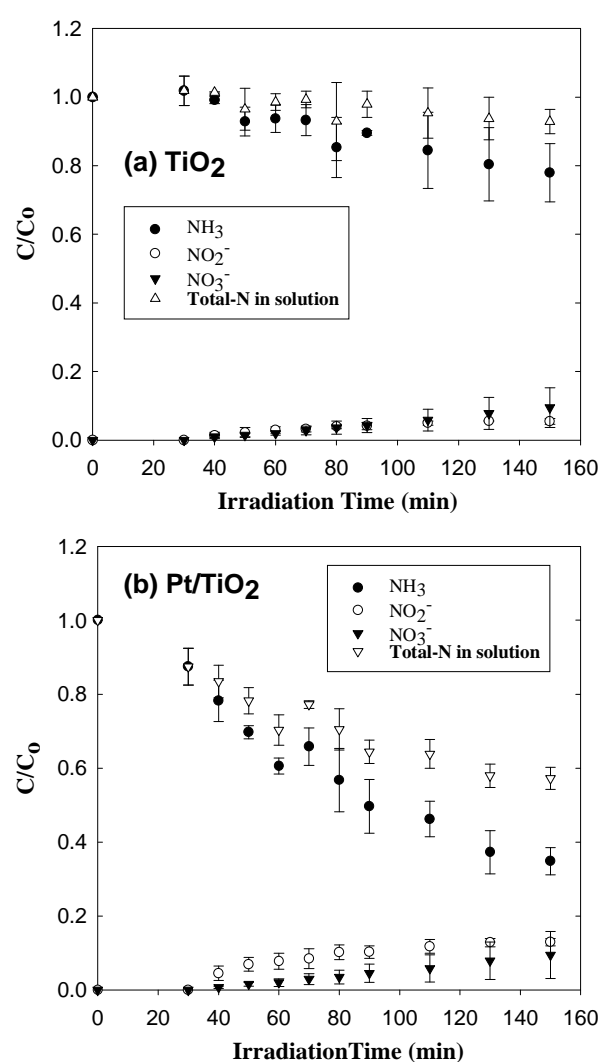


Figure 2. Photocatalytic degradation of NH₃ on (a) pure TiO₂ and (b) Pt/TiO₂ under UV irradiation. The experimental conditions were [NH₃]₀ = 100 μM, [TiO₂] = 0.5 g/L, pH = 10, and air-equilibrated.